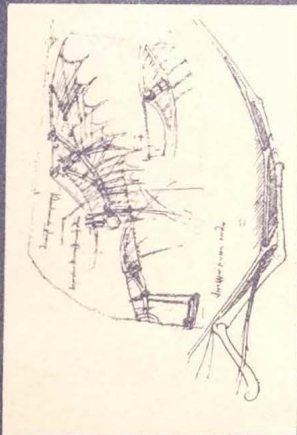


CREATIVE ENGINEERING LABORATORY, MECHANICAL ENGINEERING DEPARTMENT

# CASE STUDY CERES PROJECT

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE 39, MASSACHUSETTS



Design Case Study

PROJECT CERES 1

Composed and written as a term project  
for Product Design Course 2.735  
under the joint authorship of

Howard W. Babcock  
and  
Edward L. Davis

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Professor John E. Arnold, Supervisor

May 27, 1954

# CREATIVE ENGINEERING, INC.

100 MEMORIAL DRIVE

NEW BOSTON, MASSACHUSETTS

June 15, 1985

Dear \_\_\_\_\_

Welcome to Creative Engineering. We hope you enjoy working with us. We believe you will. Your application for employment has been given careful consideration by the Personnel Department, and they did not hesitate to recommend you to our service.

As a member of the Design and Development section of Creative you will soon get to know the men you will be working with. We think you will find them much like yourself with respect to basic interests, educational background, and engineering ability. Above all, perhaps, is your common goal: to create. If design is the highest form of engineering, then creative design-- design founded upon basic fundamentals and not upon the superfluous persistence caused by pure convention or some other inadequacy-- is truly its crowning glory.

We are not all engineers by trade. Among us you will find architects, physicists, and metallurgists, as well as persons who received training in such fields as business administration and economics. While our roster of 450 employees does not class us as a large firm, we are big as consulting firms of our type go--and healthy--and progressing--and growing.

You have perhaps already become well acquainted with our activities through the people here with whom you have talked and by reading the pamphlet "Your Career with Creative." We hope to merit your continued interest in the firm. We believe we will.

Sincerely,



Kenneth Gorham  
President

KG:ty



# INTER-OFFICE MEMO

Creative Engineering, Inc.

FROM Coordinating Council DEPT. NO. 6 DATE April 6, 1984  
TO All employees DEPT. NO.  FILE NO. 12837  
SUBJECT Information File CE-747-B on Ceres Asteroid, re  
Availability and Purpose.

This manual has been issued to you and all other members of the Creative Engineering Design and Development department as the result of action taken at the last Board of Directors meeting. It was decided at that time to provide a means for better acquainting our engineering personnel with current company projects.

Because of Creative's rapid expansion within the last few years, there has had to be increased specialization with regard to the work performed by many employees. Design and Development is somewhat more fortunate inasmuch as it still has the opportunity to perceive the problem in its entirety. Indeed, this is as it must be if we are to provide our customer with the best possible solution to his problem that we can offer.

As you may well be aware, most of our efforts are being diverted to the Ceres contract with Consolidated Mining Interests of Denver. Because of its uniqueness, this case will continue to offer problems of such diversified nature as to keep our entire staff busy for several months. Design and Development personnel especially will find a new challenge and an opportunity to call forth and utilize those ideas and schemes which heretofore were only of the most impractical nature.

The following is a collection of company correspondence, articles, design sketches and other material pertinent to the Project Ceres. Much of the factual data is from personal company files and of semi-restricted status. Hence only authorized personnel are allowed reference to the data herein and are cautioned not to divulge such information to any person not so authorized.

This is your personal copy of Project Ceres and must be kept locked in your desk or in the master file when not in use. It may not be taken outside the company unless special authorization is granted jointly by the Chief Engineer and Security Office.

It is hoped that through this report you will become more familiar with Creative's role in developing Ceres. Should you have any questions concerning the case or not specifically covered by this report, please address them to your immediate superior.

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1750 ESTES PARKWAY

DENVER, COLORADO

April 4, 1984

Mr. Niel Nelson  
Chairman, Committee on Project Planning  
Creative Engineering, Inc.  
100 Memorable Drive  
New Boston, Massachusetts

CONFIDENTIAL

Dear Mr. Nelson:

You have perhaps been informed either by reading the newstape or by seeing the news on audiovision of the arrival of the S. S. Pallos at the Equatorial Orbit Space Station yesterday. As you may recall, this ship was chartered by Consolidated Mining six months ago for expeditionary purposes.

While a complete analysis of the findings of our field team will require more time, I can tell you that we struck oil...oil, that is, in the form of uranium. The location is Ceres 1, one of the major asteroids between Mars and Jupiter. Samples of ore taken from there are currently undergoing final assay tests, but it appears that the uranium concentration is very high; so high, in fact, as to possibly warrant intersolar mining operations.

First, of course, there will have to be a detailed study made of this asteroid to determine if mining there is at all feasible. That is where your outfit enters the picture. Your expeditionary team has had experience along these lines. I am thinking in particular about the bang-up job they did on Saturn for Jones and Laughlin.

We need to know if the asteroid can be made to support human existance for prolonged periods; water and food supplies, oxygen, waste removal, and shelter are but a few of the problems. We might also mention psychological factors, for those problems which would face a living group on Ceres have certainly never been duplicated anywhere before.

Received  
Creative Eng. Inc.  
6 April 1984

Let me know if you think your firm can handle this expedition, and if so, how soon you can write up a proposal and get your "E" team to work. If we can come to terms, I will turn everything at this end over to Bob Nadler. You will perhaps recall that he worked with Phil Frick, your "E" team leader, last summer on the Brazilian iron ore job.

Further details regarding Ceres 1 will be sent you just as soon as the data brought back by our group has been analyzed and taped. This should be completed within a day or two.

Very truly yours,

A handwritten signature in black ink that reads "Willard Farnsworth, III". The signature is written in a cursive style with a prominent horizontal line at the end.

Willard Farnsworth, III  
Coordinator,  
New Areas Discovery and Development

WF/dw

CONFIDENTIAL

# CREATIVE ENGINEERING, INC.

100 MEMORIAL DRIVE

NEW BOSTON, MASSACHUSETTS

April 6, 1984

Mr. Willard Farnsworth, Coordinator  
New Areas Discovery and Development  
Consolidated Mining Interests  
1750 Estes Parkway  
Denver, Colorado

CONFIDENTIAL

Dear Mr. Farnsworth:

Upon receipt of your letter a general board meeting was called. It was decided at that time not to open any further contracts with other organizations until hearing more from you with regard to the proposed Ceres project.

We are pleased to inform you that Phil Frick and his expeditionary team will be back from a short space hop to the moon by next Saturday. Following their present assignment the group is indisposed and can begin outfitting a new expedition within a few days after their return to Terra. There are now twelve men on the E-team. You will perhaps not need the full force for your expedition, but we shall keep them available in case you do.

Until receiving your report on Ceres, then, we shall sit tight and hope that this venture may pay off for both C.M.I. and Creative. Please give my best to Bob.

Very truly yours,



Niel Nelson  
Chairman  
Committee on Project Planning

NN:my



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1750 ESTES PARKWAY

DENVER, COLORADO

April 10, 1984

Mr. Niel Nelson  
Chairman, Committee on Project Planning  
Creative Engineering, Inc.  
100 Memorable Drive  
New Boston, Massachusetts

Received  
Creative Eng. Inc.  
12 April 1984

Dear Niel;

The information brought back by our field crew has been closely investigated by a special committee composed of men from the Board of Directors as well as our own New Areas Discovery and Development group. I am happy to tell you that everything looks bright indeed.

The general train of thought here is that it appears possible to establish and maintain a working force of some size on Ceres. "Appears possible" are the key words of that statement. Our men feel it is possible to plant and operate a base on Ceres, but the problems involved will be considerable. Phil's E-team should be able to give us the answer.

Enclosed you will find the report stating all we can tell you about Ceres until further explorations have been made. After looking it over please write to us concerning your proposed manner of investigation with a rough time and estimated expense account.

Sincerely yours,

*Willard Farnsworth III*

Willard Farnsworth, III  
Coordinator,  
New Areas Discovery and Development

CONFIDENTIAL

encl.  
WF/dw

# SOLAR PLANET REPORT

SOLAR BODY Sun NAME Ceres I  
FILE NO. D-423-0032 ATMOSPHERE None apparent  
MASS/Tm  $1.25 \times 10^{-4}$  DIAMETER: Major 572 mi. Minor 338 mi.  
MEAN DISTANCE FROM SUN 2.78 A.U. INCLINATION TO ECLIPTIC  $10^{\circ}36'56''$   
MEAN SURF. GRAVITY  $3.43 \times 10^{-2} \times$  MEAN ORBITAL VEL. 17.89 km/sec or  
LENGTH OF DAY 47.160 hrs. LENGTH OF YEAR  $11.1 \text{ mi/sec}$   
 $1681.5 \text{ msd}$   
TRAJECTORY DISTANCE FROM TERRAN  $443 \times 10^6$  miles  
MAX. TEMP. (sun at zenith) 10°F TEMP. (sun at nadir) -53°F  
MIN. TEMP. (polar) approx. -200°F

\*Note: Gravity varies from a maximum of  $6.86 \times 10^{-2}$  at the poles to a minimum of  $2.39 \times 10^{-2}$  at the equator. Gravity is given relative to mean surface gravity of earth. 1

CONFIDENTIAL

## REMARKS AND EXPLANATORY NOTES

Received  
Creative Eng. Inc.  
12 April 1984

1. On-location checks indicate large quantities of highly concentrated uranium ore.
2. Terrain is basically rocky, but so far as we can tell the entire surface is covered by a layer of rock dust to a depth of from two to five inches. This is perhaps the result of meteor collisions, although the meteor count averaged over our seven day stay was only .046.
3. Topography is mountainous. This, combined with the thick layer of dust, makes transportation difficult, although the lower gravity certainly helps overcome this handicap once one can learn to adapt his actions to it. It should be noted that because of the pendulum-like motion of a person's legs when he walks, the natural speed of locomotion is slower than on Terran by a factor of the square root of the gravity ratio. The magnitude of this factor, using mean values of gravitation on Terran and Ceres, equals .1825. Our team developed a method of rapid locomotion, that of using a combination of a very long, very slow stride--like a moving picture in slow motion of a man on Terran doing a running broad jump. In this manner one can cover as much as thirty feet in a single stride and can bound along at speeds of about ten mph for some time without tiring.
4. There being no atmosphere, all supplies of oxygen had to be brought along in the ship. Should a permanent colony be established here later on it would undoubtedly be advantageous

from an economical and self-sufficing standpoint to establish an oxygen-carbon dioxide balance through the importation of plant life, possibly algae.

5. Compared to Terran, temperatures are much lower, but still mostly above  $-100^{\circ}$  F. During the long night in the polar zones it is estimated that the temperature drops only to  $-200^{\circ}$  F due to latent heat in the soil, and possibly some heating due to thermal radiations from the uranium deposits. These temperatures were taken from the standard blackbody sphere located twelve feet above the ground.

6. The asteroid is not spherical in shape; rather it has the general shape of an ellipsoid. The variation between the major and minor axes results in a variation in surface gravity of almost 300 percent.

7. Radio reception and transmission between both Terran and Ceres and between Mars and Ceres was excellent at all times. No communication interference is anticipated.

8. No life on any kind exists on the asteroid. Through suitable hydroponic installations plant life can perhaps be inaugurated.

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# CREATIVE ENGINEERING, INC.

100 MEMORIAL DRIVE

NEW BOSTON, MASSACHUSETTS

April 13, 1984

Mr. Willard Farnsworth, III  
Coordinator,  
New Areas Discovery and Development  
Consolidated Mining Interests  
1750 Estes Parkway  
Denver, Colorado

CONFIDENTIAL

Dear Willard;

Your report on Ceres has been received and reviewed by the Project Planning Committee. We are of the opinion that great possibilities may exist by the future colonization of this planetoid. Accordingly, we have recommended to the Board of Directors that an all-out effort be made on Creative's behalf in connection with C.M.I.'s operations as soon as we receive your final approval of our proposal.

Phil Frick returned yesterday, and I have told him of the proposed expedition. Henceforth, until we have learned more about conditions on Ceres, our end of the project will lie in Phil's hands. He will get in touch with Bob Nadler shortly and together they can work out the details of the trip.

I understand you are giving the keynote address at the annual American Smelters and Refiners Society convention next month. I will be there, of course, and we can get together then perhaps and hash over this project in a little more detail.

My best personal regards to both you and Mrs. Farnsworth.

Sincerely,



Niel Nelson  
Chairman,  
Committee on Project Planning

NN:my

# CREATIVE ENGINEERING, INC.

100 MEMORIAL DRIVE

NEW BOSTON, MASSACHUSETTS

April 18, 1984

Mr. Robert Nadler  
Field Chief, New Areas Discovery and Development  
Consolidated Mining Interests  
1750 Estes Parkway  
Denver, Colorado

CONFIDENTIAL

Dear Bob,

Niel Nelson, our chairman of the Committee on Project Planning, just tossed your whole dirty mess in my lap. My boys and I just returned from a Lunar job last Thursday, and we were all set to take off for a little fishing trip in Canada. So what happens? You and your eagle-eyed brethren have to go and find nuclear fire water riding on a piece of space junk between Mars and the Big Boy! Just shows to go you what horrible taste I have when it comes to picking friends...

Since this whole deal is a result of your space piddling, the least you can do is make life a little easier for me by clueing me as to the M.O. you followed for Ceres, re, oxygen, food, supplies, water and shelter. (Knowing you as I do, you undoubtedly found ship space for a couple cases of Scotch, too.)

While you're at it, send along the punch tape data for matching trajectories with that rockpile. We do not have our own ship yet, but I hope to be able to charter the S. S. Gannymede. I've used it before, and it is well suited for expeditionary work.

My very best to Susan.

So long,

*Phil*

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1750 ESTES PARKWAY

DENVER, COLORADO  
April 20, 1984

Mr. Philip Erick  
Commander, Expeditionary Team  
Creative Engineering, Inc.  
100 Memorable Drive  
New Boston, Massachusetts

Dear Phil,

CONFIDENTIAL

I did not have scotch aboard the ship.

Sorry, old man, about your fishing trip. Don't feel too badly about it. I have two weeks off starting next Monday, so I'll take it for you.

This trip should be a snap for you. If you can schedule your time so as to blast off at 04:36 on the 7th of next month, you should have no trouble making a minimum fuel run to Ceres. Ceres will be running a 36° perihelion lead with respect to Terran at that time, and a six year old child--nay, even you--could match trajectories.

You'll need about 5 pounds of oxygen per man per day without reclamation while on Ceres. This number may actually be high, because the easy, untiring locomotion may slow the metabolism rate considerably.

Food will run about standard (six ounces per man per day of K-27 rations). K-27 is a good ration to use since they keep so much better at low temperature than the old K-23's. And take a good supply of Low-G pills. Romping around in a gravity field that is practically nil can be mighty invigorating, but only after you've become accustomed to it. Old Otto Sellinger (remember him?) thought he had been a spaceman long enough to get around without them. He did...for one day. He spent the rest of the time in the ship's sick bay.

Received  
Creative Eng. Inc.  
22 April 1984



I've enclosed a thumbnail sketch of the asteroid with our touchdown position indicated. Just to the north is a low mountain range. Beyond that, about a mile from our location is a very smooth and level plain which is probably better suited for landings than the one we chose. We left some extra provisions from our on-location allotment which we cached and left a couple of hundred yards from our blast-off position. Look for a yellow marker flag if you need them. We also left a meteor counter and temperature recorder operating so that you will have a little more info on average conditions. There are also a couple of counters going for cosmic rays and other stray radiations.

As for shelter, we used the space ship. No sense setting up anything permanent just so you can take it over. Expect some meteors, but with the low G you shouldn't have to worry much.

Watch your geigers! Johnny Ewing, our radiation man, found some fairly high gamma ray readings, and he believes there may be areas of sufficiently high concentrations as to prohibit any but a very cautious approach.

One more procaution!! This is leap year, and if you want to retain your statis as a jolly bachelor here on Terran you better watch your step. I think Ann is dying to act as a little match-maker again. 'Nuff said.

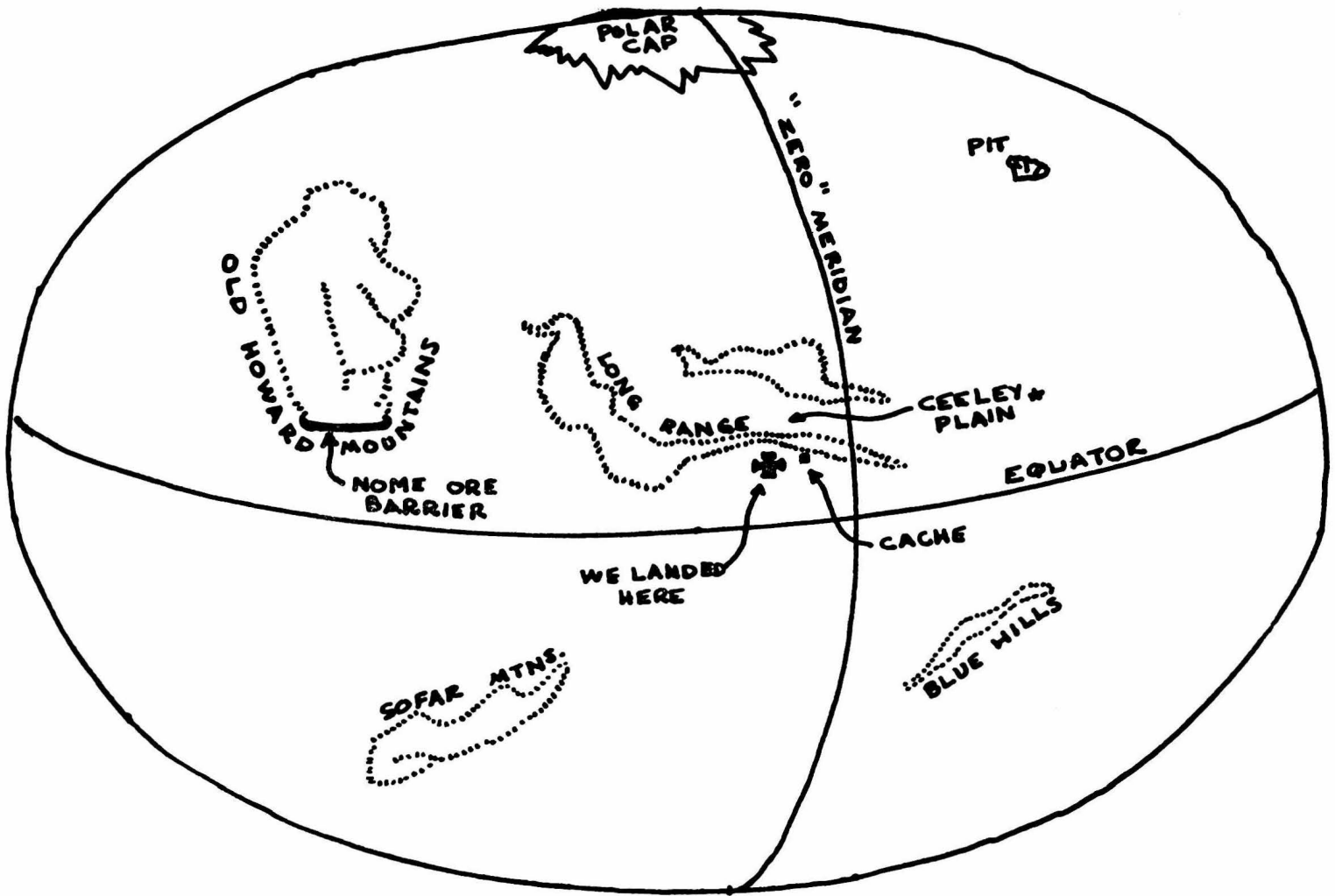
It was rye.

As ever,

  
**CONFIDENTIAL**

# SKETCH OF Ceres 1

CONFIDENTIAL



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Received  
Creative Eng. Inc.  
22 April 1984

\* GOOD LANDING PROSPECTS HERE

Carolyn —

The team will be leaving in a few days for Ceres — standard expeditionary stuff — Please get in touch with Charles Cotter at the Space Charter Service and see if we can get the S.S. Sannymede for a couple months. If it is tied up, the S.S. Pegasus will do. But we would like to have the Sanny. CONFIDENTIAL

Heard that Janet is getting married and leaving the office. I won't be able to make the office party. Please extend my best wishes. We're all going to miss her.

Phil



# CREATIVE ENGINEERING, INC.

100 MEMORIAL DRIVE

NEW BOSTON, MASSACHUSETTS

Ceres  
May 17, 1984

Mr. Niel Nelson  
Chairman, Committee on Project Planning  
100 Memorable Drive  
New Boston, Massachusetts

CONFIDENTIAL

Dear Niel;

Arrived last week, as you by now must have heard, but haven't had a chance to do much more than organize the team and get the boys generally squared away. I haven't got much to report, but I thought you would like to hear a word or two anyway.

As we expected, there was no trouble landing. We coasted up, decelerated and settled down in the Ceeley Plain, about 17 miles from the equator. The boys and I were certainly glad to be on solid land again.

Your selection of tapes and films was excellant, but one can never quite relieve the boredom of travel. It was great to have our feet on the ground, even though it was a bit difficult to keep them there. Since the adoption of simulated gravity in the ships few of us have known the feeling of weightlessness in working quarters.

We started the prospecting team off two days ago-- they'll be gone now for about three weeks. We're keeping in touch by phone, but the first precise data will have to wait for the assay and the grid plots. There seems to be quite sizeable pockets of both carnotite and pitchblend. Which reminds me...have the chemists come any further in their work of extracting water and oxygen from carnotite during the refining process? If they can evolve some nice elegant process it will certainly save some freight charges, and make living here a bit more secure.

The new pressure suits are really terrific! The old ones just can't compare in comfort and freedom. And there have been no cases of meteor rash thus far, which is certainly encouraging. Speaking of meteors, it is gratefying, especially from the moral standpoint, to see how damn little meteor scars this rockpile has.

Quite a difference from our old friend the moon.

C.M.I.'s recorders were still operating when we arrived, and we are in the process of analyzing the data now.

I'll radiograph you again as soon as we have some real dope to feed back to you. I've begun a list of some problems that I think may be important, but that can wait for a later date.

My best to everyone at Creative.

*Phil*

P.S. I sure do miss those nice warm New Boston winter days.

COPY

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# WORK ORDER

ISSUED TO Henry Masters DATE May 21, 1984  
GROUP NO. 9 BY ORDER OF Niel Nelson, Chairman, C.P.P.  
SUBJECT Temporary housing facilities for Ceres 1

---

CONFIDENTIAL

Henry--

As you know, Phil Frick's E-team has definitely established the location of extensive highly concentrated uranium deposits on the Ceres 1 asteroid. In a closed session with the Board of Directors of Consolidated Mining yesterday it was decided that small scale mining operations should be gotten underway as soon as possible.

Accordingly, C.M.I. intends to send about 25 men to Ceres within three months. Before this time, of course, living accommodations of some kind will have to be provided. The importance of adequate well-designed housing can not be overemphasized.

Inasmuch as the time is limited and because the problems which will be encountered will perhaps be many and of an unforeseeable type, I recommend that you have your group stop current work on all but Class AA projects and concentrate its talent on Ceres housing. I would like to get in touch with you, Thursday if possible, and discuss specifications in some detail. In the meantime, here is a general list of design criteria upon which you will have to base your work.

1. Because of high freight rates, any structure should have high strength per volume and low weight. Don't forget that we are designing for very low gravity.
2. Any structure should be prefabricated. Keep in mind that cargo space is limited and expensive, so that packaging must be concentrated.
3. Corrosion problems will be, in a sense, reversed. The only corrosive action that will occur will be inside the units where water and oxygen are present. Only very light meteor shields are necessary, since the meteor count averages only .046. As a matter of interest, our people on Ceres have taken to leaving everything possible outside that they wish to protect from corrosive action. Garages for speedmobiles would not find a big market on Ceres.

4. Rapid and easy assembly on location. The men will need to establish housing in a hurry, and cannot afford long assembly time. It must also be kept in mind that they will have no special apparatus available other than ordinary hand tools with which to work. Any fabrications involving special handling or assembling equipment is out.
5. Pressurization of the units will be necessary. Otherwise the primary purpose of these units, i.e., adequate space for unrestricted work, exercise and relaxation will not have been accomplished.

-----

This will generally outline the attributes and restrictions that you will face in this design project. We can discuss particular problems, if any, at our next meeting. I am confident that you and your group will do as well as always.

Hope to see you Thursday.

*Neil*

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Kiel,

CONFIDENTIAL

Got just the thing you want —  
one of those "Bucky" Geodesic Domes  
of the type that we designed for the  
Martian Substation B back in '82.

I'll give you the details at lunch  
tomorrow.

Henry

CONFIDENTIAL



CREATIVE ENGINEERING, INC.  
100 MEMORIAL DRIVE  
NEW BOSTON, MASSACHUSETTS

Ceres 1  
June 11, 1984

Mr. Niel Nelson  
Chairman, Committee on Project Planning  
Creative Engineering, Inc.  
100 Memorable Drive  
New Boston, Massachusetts  
United States of America

CONFIDENTIAL

Dear Niel;

The field teams have just about finished the preliminary grid survey and it really looks good. We have mapped all but the north polar zone, and will probably not bother with that portion until "summer" when we can have a little light and heat from the sun. In any case, by bead and geiger tests, we have definitely established some highly concentrated fields, primarily pitchblend, but also some sizable deposits of carnotite. The major pitchblend deposits assay at about 80% uranium oxide, much higher than the usual on earth. The scintilliscopes really glow at night when we use them.

As a first guess, it appears that Ceres may eventually yield uranium somewhere in the order of ten trillion tons, or in dollar value about twenty quadrillion dollars market price at the present level of \$2.00 per pound for pure ore.

Before we fill our coffers with gold, however, we have a few minor problems--like how the hell are we going to mine the stuff. For instance, on the most primitive level, it is difficult to use a pick on pitchblend since the rebound carries pick and man thirty or forty feet off the ground. We have now made it s.o.p. for the men to secure themselves to the ground so they don't get too carried away. Your boys at Creative have a nice problem cut out for themselves in the design of suitable mining equipment.

There are several other major problems where I feel that immediate work should be started. Some of them are:

1. Timekeeping devices for our rotational period. Every "day" it gets light at a different hour.

2. Exercising machines. Might combine them with some sort of a game to keep the men using them. Muscles deteriorate quickly in the low gravity zones.
3. Beds and other furniture.
4. Waste disposal equipment and plumbing.
5. Cooking and eating utensils. My, how that food does slop now.
6. Transportation devices, both for us and for the ore and equipment.
7. All kinds of mining equipment adapted for low gravity use.

These are but a few that come to mind at the moment. With not too much imagination one can list several more problems which will have to be solved before this place is really habitable.

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# Interplanet Freighting Service

61 Broadway  
New York, New York

June 7, 1984

Mr. Niel Nelson  
Chairman, Committee on Project Planning  
Creative Engineering, Inc.  
100 Memorable Drive  
New Boston, Massachusetts

CONFIDENTIAL

Dear Mr. Nelson:

In answer to your request of June 4 I am forwarding to you an estimated freight rate schedule between Terran and Ceres. The enclosed chart reflects the general relation between ship capacity and operating costs, as shown by volume and density parameters. As has been our policy in the past with new routes, these estimated rates may vary when future operation shows deviations of cost factors.

We estimate that it will cost about \$1000 a ton to ship your primary cargo, uranium oxide; or, as shown on the enclosed graph, at specific gravity of 7.31, cost per cubic foot will be \$228. This figure assumes that full cargo capacity will be used on the Terran to Ceres run. Empty runs will, of course, approximately double costs for return cargos.

We are very grateful for your continued confidence in our company, and hope that any future transportation questions may be answered by us. We wish you great success in your new venture.

Very truly yours,

*Lair Locke*

Lair Locke  
Economic Coordinator

Received  
Creative Eng. Inc.  
9 June 1984

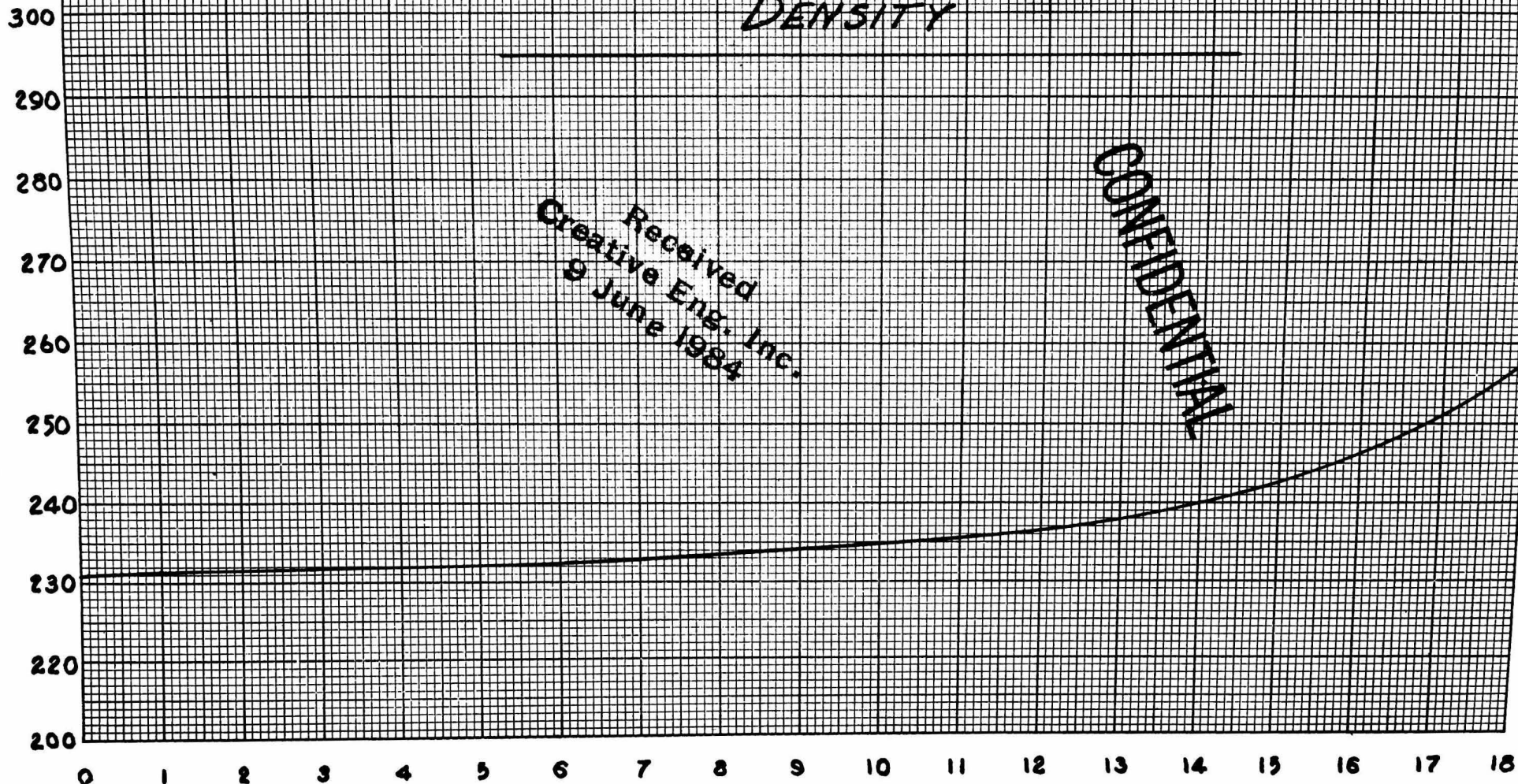
LL/bw

SHIPPING COST PER CUBIC FOOT  
(PACKED VOLUME) FOR PACKED  
DENSITY

Received  
Creative Eng. Inc.  
9 June 1984

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DOLLARS PER CUBIC FOOT



SPECIFIC GRAVITY (PACKED)



# INTER-OFFICE MEMO

Creative Engineering, Inc.

FROM Henry Masters DEPT. NO. \_\_\_\_\_ DATE June 15, 1985  
TO Niel Nelson DEPT. NO. \_\_\_\_\_ FILE NO. 12837  
SUBJECT Autonomous Core for Ceres I Project

---

Niel—

Suprise, suprise. About all we had to do was reach into the files and pull out the enclosed design to solve your utilities problem. Sometimes it pays off to design for the far distant future. You may not believe this, but the enclosed design, the "Autonomous Core" was proposed way back in 1951 by Harold Horowitz while he was still at MIT (long before he had any idea that he would become first Secretary of the Exterior). Naturally, the technology is era 1951, but the basic scheme is still good.

Since we can't possibly supply the normal 30 to 50 gallon per day per man demand for water, this unit should answer our problem. Body, cooking, and washing wastes are adsorbed and purified by the ethylenediamene, and the liquid is then distilled by low pressure. The waste residue can then be burned, and the fluid is fractionally distilled to recover the water. The only water losses in the home will occur through evaporation--at the most a gallow a day.

By replacing the boiler with a reactor, using sodium rather than tetracresylsilicate, an exterior condenser as our heat sink, redesigning the plumbing fixtures for low gravity, and institut ing other standard changes the Core will meet all requirements for use on Ceres.

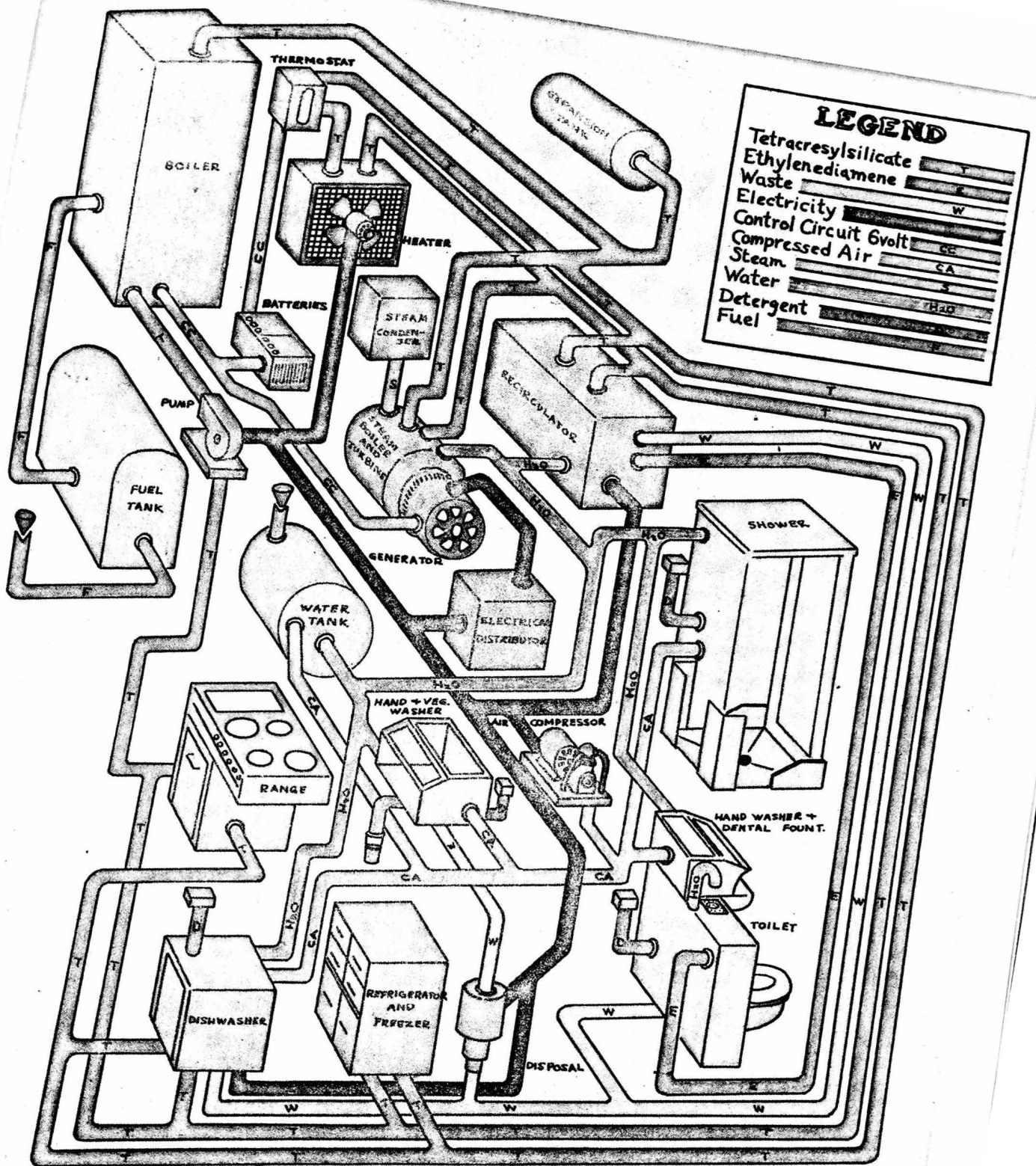
If you will get your men to work out the above problems I think that the phrase "all the comforts of home" can be used in sales talks when we start hiring for the Ceres project.

*Henry*

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"AUTONOMOUS CORE"  
Self-Sufficient House

## DESIGN CHECK LIST

Special considerations must be kept in mind when designing any product intended for Terranian manufacture and Cerian use. While all fundamental engineering principles are in effect just as much as ever, the nature of this project often permits the turning of heretofore impractical schemes into practical products.

A list of things to keep in mind when doing any design work is given below. The merits of all tentative designs should be checked against this list before they are approved and further work devoted to them.

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1. The low gravity permits the use of lighter structures which would be considerably underdesigned by Terranian standards. Materials of lower strength may be used when they possess other merits which warrant their use. For example, it is conceivable that a structural unit such as a house be made of paper or similar material.

Supporting structures which could otherwise be light except that buckling may occur (as in narrow columns) might still be acceptable if the impressed loading could be taken up in tension rather than compression. Remember the wire spokes in a bicycle wheel.

2. Because Ceres possesses no atmosphere, corrosion as we know it on Terran is non-existent. Hence this is a factor which must be allowed for only in the design of products intended for use within housing units where an artificial atmosphere is provided.

3. Facilities for the assembly and fabrication of products on the asteroid will be few for some time. It is therefore very important that any item involving assembly or maintenance on Ceres be designed so that this work can be done with the tools available. In general these will consist of common hand tools, such as wrenches, hammers, pliers, hand drills, hand saws and the like. Fastenings must be kept simple. Nuts, bolts, screws, nails and cotter pins should be used wherever feasible.

4. Freight rates are of necessity very high, and the space available on any ship is limited. At present the dimensions of the holds of the larger space ships are 40 feet in length by 16 feet in diameter, or about the size of a standard box car.

Bulky products are highly undesirable. This can be overcome somewhat by designing products which can be shipped in a knocked-down condition and then put together on Ceres. Also, the advantage of using light materials such as aluminum and magnesium wherever possible is obvious.

5. Articles whose successful operation depends upon a constant gravity field are worthless. The gravitational field on Ceres varies as much as 300 per cent, depending on the location. This must be remembered, for example, if the design of a weighing scale were to be attempted.

6. Large energy supplies, while not available at present, will eventually be derived from solar power. Do not scrap a design which you feel possesses merit but which may not be able to be used right now.

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THERE IS NOTHING SO IMPORTANT IN THE FIELD OF CREATIVE DESIGN AS THE ABILITY TO RECOGNIZE A DEAD HORSE. ONCE RECOGNIZED, IT SHOULD NOT BE RETAINED BUT SHOULD BE TAKEN OUT AND BURIED AT ONCE, WITH AS LITTLE CEREMONY AS POSSIBLE.